

Emittance Measurements for High Charge State Ion Beams *

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In order to investigate the ion-optical parameters of the AECR-U injection line [1] into the 88-Inch Cyclotron, an electrostatic-deflection-type emittance scanner has been designed and constructed [2]. It allows fast on-line measurements, while tuning the ion beam through the cyclotron. Systematic ion beam emittance measurements in both the horizontal (xx') and vertical plane (yy') were performed for a wide range of ions. The results indicate a strong mass dependence of the normalized beam emittance. For example the normalized rms emittance for protons ($0.24 \pi\text{-mm-mrad}$) is four times higher than for O^{6+} ($0.06 \pi\text{-mm-mrad}$) and about 8 times higher than Kr^{19+} ($0.03 \pi\text{-mm-mrad}$).

Figure 1 shows the dependence of the normalized xx' emittance values for helium and charge state distributions of oxygen, krypton and bismuth on the mass to charge ratio M/Q . A similar dependence was measured for the vertical plane. The emittance values for a particular charge state distribution were measured at the same plasma condition, only the settings for the Glaser lens and the analyzing magnet were changed. The emittance decreases systematically with increasing mass. Within a charge state distribution for a particular element the measured emittance decreases for higher charge states. These results are consistent with the model that highly charged ions are created closer to the center of the ECR plasma, where hot electrons are confined. This hot electron core also confines the highest charge state ions in the electrostatic well. The low charge state ions can be produced at the outer shell of the ECR plasma and therefore have higher emittance values. This is also in agreement with the observation, that the extracted currents for high charge state ions decrease less than those for low charge state ions after reduction of the extraction hole diameter [3].

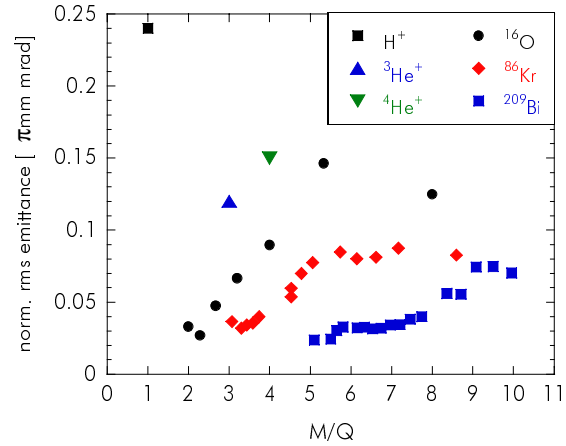


Fig. 1. Comparison of the normalized emittance values for different masses and charge states

The measurements also showed that the emittance value is predominantly dependent on the charge state and not on the current at these ion beam intensities. For instance the ion beam emittance of $18.8 \mu\text{A}$ of Bi^{21+} was measured to be $0.07 \pi\text{-mm-mrad}$, while the emittance of $18 \mu\text{A}$ of Bi^{32+} was $0.03 \pi\text{-mm-mrad}$.

Because of its reliability and speed, the emittance scanner has become an extremely useful ion source online tuning aid for the 88-Inch Cyclotron injection line.

Footnotes and References

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